Table 2.1 Whole-Rock Chemical Composition of Basalt from the Columbia River Plateau, Sample BCR-1[a]

SiO_2	54.06	Ag	27*	Er	3.63	Nd	28.8	Tb	1.05
TiO_2	2.24	As	650	Eu	1.95	Ni	(13)	Te	(4.9*)
Al_2O_3	13.64	Au	(0.66*)	F	490	Pb	(13.6)	Th	5.98
Fe_2O_3	3.59	Ba	681	Ga	22	Pr	6.8	Tl	0.3
FeO	8.88	Be	(1.6)	Gd	6.68	Rb	47.2	Tm	0.56
MnO	0.18	Bi	47*	Ge	1.5	Re	0.84	U	1.75
MgO	3.48	Br	(72*)	Hf	4.95	Rh	(0.23*)	V	407
CaO	6.95	Cd	130*	Hg	(7.9*)	S	410	W	(0.44)
Na_2O	3.27	Ce	53.7	Ho	1.26	Sb	0.62	Y	38
K_2O	1.69	Cl	59	In	92*	Sc	32.6	Yb	3.38
P_2O_5	0.36	Co	37	La	24.9	Se	(88*)	Zn	129.5
H_2O^+	0.75	Cr	(16)	Li	12.9	Sm	6.59	Zr	190
H_2O^-	0.81	Cs	0.96	Lu	0.51	Sn	(2.7)		
CO_2	0.03	Cu	(19)	Mo	(1.6)	Sr	330		
LOI	1.67	Dy	6.34	Nb	(14)	Ta	0.81		
Total	99.93								

[a]Major element oxides in wt.%. Less certain values in parentheses. *, Trace element concentration in parts per billion (ppb); all other trace elements in parts per million (ppm).
Data from Govindaraju (1989).

Table 2.2 Average Chemical Compositions of Some Common Rock Types (Recalculated Volatile-Free to Total 100%) and Their Normative Compositions[a]

	Phonolite	Syenite	Trachyte	Granite	Rhyolite	Granodiorite	Dacite	Diorite	Andesite
n	340	517	534	2485	670	885	651	872	2600
SiO_2	57.43	59.63	62.31	71.84	73.95	66.91	65.98	58.34	58.70
TiO_2	0.63	0.86	0.71	0.31	0.28	0.55	0.59	0.96	0.88
Al_2O_3	19.46	16.94	17.27	14.43	13.48	15.92	16.15	16.92	17.24
Fe_2O_3	2.85	3.09	3.04	1.22	1.50	1.40	2.47	2.54	3.31
FeO	2.07	3.18	2.33	1.65	1.13	2.76	2.33	4.99	4.09
MnO	0.17	0.13	0.15	0.05	0.06	0.08	0.09	0.12	0.14
MgO	1.09	1.90	0.94	0.72	0.40	1.76	1.81	3.77	3.37
CaO	2.78	3.59	2.38	1.85	1.16	3.88	4.38	6.68	6.88
Na_2O	7.96	5.33	5.57	3.71	3.61	3.80	3.85	3.59	3.53
K_2O	5.36	5.04	5.07	4.10	4.37	2.76	2.20	1.79	1.64
P_2O_5	0.18	0.30	0.21	0.12	0.07	0.18	0.15	0.29	0.21
Q		0.83	5.00	29.06	32.87	22.36	22.73	10.28	12.37
C				0.92	1.02	0.26			
Or	30.96	29.29	29.41	24.50	25.44	16.11	12.82	10.42	9.60
Ab	35.48	44.34	46.26	31.13	30.07	31.73	32.07	29.96	29.44
An	1.50	7.24	7.05	8.04	4.76	17.34	20.01	24.40	26.02
Lc									
Ne	16.50								
Di	6.89	5.35	2.14				0.11	4.67	4.84
Wo	0.73								
Hy		4.16	2.06	3.37	1.34	7.40	5.73	12.56	9.49
Ol									
Mt	4.05	4.41	4.33	1.75	2.14	2.00	3.53	3.63	4.74
Il	1.18	1.60	1.34	0.58	0.54	1.03	1.09	1.80	1.65
Ap	0.41	0.70	0.49	0.28	0.17	0.42	0.34	0.68	0.50

	Trachyandesite	Trachybasalt	Basalt	Basanite	Nephelinite	Anorthosite	Lherzolite	Harzburgite	Dunite
n	232	161	3594	165	176	104	179	206	93
SiO_2	59.30	49.99	49.97	45.16	41.81	51.12	45.43	43.73	41.04
TiO_2	1.10	2.44	1.87	2.56	2.74	0.65	0.45	0.28	0.10
Al_2O_3	17.03	16.89	15.99	14.99	14.76	26.29	4.39	2.57	1.95
Fe_2O_3	3.32	3.75	3.85	4.02	5.64	0.98	5.15	6.00	3.85
FeO	3.27	6.28	7.24	7.65	6.35	2.10	7.44	7.09	10.05
MnO	0.16	0.16	0.20	0.16	0.27	0.05	0.17	0.16	0.76
MgO	2.62	5.25	6.84	8.71	6.58	2.16	30.31	36.34	40.66
CaO	5.06	8.03	9.62	10.39	12.25	12.69	5.68	3.18	1.08
Na_2O	4.44	4.02	2.96	3.62	4.93	3.20	0.59	0.34	0.21
K_2O	3.27	2.59	1.12	2.00	3.56	0.66	0.27	0.15	0.09
P_2O_5	0.42	0.60	0.35	0.75	1.10	0.09	0.12	0.14	0.21
Q	7.80								0.80
C									0.47
Or	19.00	15.06	6.52	11.61	3.16	3.86	1.50	0.83	1.69
Ab	36.80	29.39	24.66	12.42		23.16	4.66	2.60	1.17
An	16.58	20.10	26.62	18.38	7.39	49.71	7.99	4.17	
Lc					13.57				
Ne		2.23		9.55	21.95	1.89			
Di	3.95	11.85	14.02	21.03	32.36	8.61	13.54	6.93	
Wo							21.48	21.13	14.48
Hy	6.06		15.20				36.31	46.22	67.38
Ol		8.28	1.50	12.38	2.32	2.01	7.00	7.94	5.20
Mt	4.73	5.36	5.49	5.72	7.95	1.40	0.79	0.50	0.18
Il	2.07	4.55	3.49	4.77	5.05	1.22	0.26	0.30	0.47
Ap	0.97	1.38	0.82	1.74	2.51	0.21			

[a]The number of analyses averaged is represented by *n*. The rock-type names are those used by the author of the report in which the analyses were published; that is, the names are not based on the IUGS classification. In most instances there is little discrepancy between the original report writer's name and the IUGS name.

Data from Le Maitre (1976).

Table 2.3 Generally Compatible Trace Elements and the Minerals in Which They Occur

Major Mineral	Simple Formula	Compatible Trace Elements
Olivine	$(Mg, Fe)_2SiO_4$	Ni, Cr, Co
Orthopyroxene	$(Mg, Fe)SiO_3$	Ni, Cr, Co
Clinopyroxene	$(Ca, Mg, Fe)_2(Si, Al)_2O_6$	Ni, Cr, Co, Sc
Hornblende	$(Ca, Na)_{2\text{-}3}(Mg, Fe, Al)_5$ $(Si, Al)_8O_{22}(OH, F)_2$	Ni, Cr, Co, Sc
Biotite	$K_2(Mg, Fe, Al, Ti)_6$ $(Si, Al)_8O_{20}(OH, F)_4$	Ni, Cr, Co, Sc, Ba, Rb
Muscovite	$K_2Al_4(Si, Al)_8O_{20}(OH, F)_4$	Rb,Ba
Plagioclase	$(Na, Ca)(Si, Al)_4O_8$	Sr, Eu
K-feldspar	$KAlSi_3O_8$	Ba, Sr, Eu
Accessory Minerals[a]		
Magnetite	Fe_3O_4	V, Sc
Ilmenite	$FeTiO_3$	V, Sc
Sulfides		Cu, Au, Ag, Ni, PGE[b]
Zircon	$ZrSiO_4$	Hf, U, Th, heavy REEs
Apatite	$Ca_5(PO)_3(OH, F, Cl)$	U, middle REEs
Allanite	$Ca_2(Fe, Ti, Al)_3(O, OH)$ $(Si_2O_7)(SiO_4)$	Light REEs, Y, U, Th
Xenotime	YPO_4	Heavy REEs
Monazite	$(Ce, La, Th)PO_4$	Y, light REEs
Titanite (sphene)	$CaTiSiO_5$	U, Th, Nb, Ta, middle REEs

[a]Accessory minerals constitute only a small fraction of rock but their very high partition coefficients create a disproportionate influence on bulk distribution coefficients.

[b]**Platinum group elements:** Ru, Rh, Pd, Os, Ir, Pt.

Table B.2. Calculation of the Normative Composition of the Low-K Basaltic Andesite in Table 13.6

	Wt.% Oxide	Formula Weight	Formula Proportion	*Ap*	*Il*	*Or'*	*Ab'*	*An*	*Mt*	*Rem*	*Di'*	*Hy'*	*Q*
SiO_2	53.29	60.08	0.8870			0.0192	0.2136	0.2582			0.0912	0.1625	0.1423
TiO_2	0.91	79.87	0.0114		0.0114								
Al_2O_3	17.13	102.0	0.1679			0.0032	0.0356	0.1291					
Fe_2O_3	3.47	159.7	0.0176*						0.0176				
FeO	7.83	71.85	0.1172*		0.0114				0.0176	0.0910	0.0199	0.0711	
MnO	0.20	70.94	0.0028										
MgO	4.72	40.30	0.1171							0.1171	0.0257	0.0914	
CaO	9.87	56.08	0.1760	0.0013				0.1291		0.0456	0.0456		
Na_2O	2.21	62.00	0.0356				0.0356						
K_2O	0.30	94.20	0.0032			0.0032							
P_2O_5	0.06	141.9	0.0004	0.0004									
Wt.% normative mineral				0.13	1.73	1.78	18.67	35.92	4.07		10.50	18.56	8.55

* Proportions adjusted so that the molecular Fe_2O_3/FeO ratio = 0.15. FeO/MgO = 0.7771 in *Rem*.

Table B.3. Calculation of the Normative Composition of the Orangeite in Table 13.11

	Wt.% Oxide	Formula Weight	Formula Proportion	*Ap*	*Il*	*Or'*	*Ks*	*Ac*	*Mt*	*Rem*	*Di'*	*Hy'*	*Ol'*	*Lc*	*Or*
SiO_2	35.09	60.08	0.5841			0.1500	0.0059	0.0116			0.0928	0.7269	0.3631	0.0324	0.0324
TiO_2	1.06	79.87	0.0133		0.0133										
Al_2O_3	2.55	102.0	0.0250			0.0250								0.0196	0.0054
Fe_2O_3	7.78t	159.7	0.0113*					0.0029	0.0113						
FeO		71.85	0.0749*		0.0133				0.0113	0.0524	0.0032	0.0492	0.0493		
MnO	0.15	70.94	0.0021												
MgO	29.02	40.3	0.7201							0.7201	0.0432	0.6769	0.6768		
CaO	3.49	56.08	0.0622	0.0158						0.0464	0.0464				
Na_2O	0.18	62.00	0.0029					0.0029							
K_2O	2.91	94.20	0.0309			0.0250	0.0059							0.0196	0.0054
P_2O_5	0.68	141.9	0.0048	0.0048											
Wt.% normative mineral (Step. 30.)				1.57	2.02	0	0.91	1.34	2.62		10.14	0	52.63	8.56	3.01

Step 22. $D = 0.4023$

23. $D > Hy'/2 = 0.7261/2 = 0.3631$; $Ol' = 0.3631$; $Hy = 0$; $D_1 = 0.4023 - 0.3631 = 0.0392$

24. $D_2 = D_1 = 0.0392$

25. $D_2 > 4Ab' = 0$; $Ne = Ab' = 0$; $D_3 = D_2 - 4Ab' = 0.0392$

26. $D_3 < 2Or' = 0.0500$; $Lc = D_3/2 = 0.0392/2 = 0.0196$; $Or' - D_3/2 = 0.0250 - 0.0196 = 0.0054$

* Proportions adjusted so that the molecular Fe_2O_3/FeO ratio = 0.15. FeO/MgO = 0.0728 in *Rem*.